The Role of Ocean Color Data and Primary Productivity Models in Assessing the Skill of Numerical Circulation Models

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LONG-TERM GOALS

The long-term goal of this effort is to improve the skill of modern 3-D numerical ocean circulation models used for studying the oceans and, in operational centers, for nowcasting/ forecasting the oceanic state.

OBJECTIVES

The principal objective of this research is to determine the utility of satellite ocean color data and primary productivity models in assessing the skill of numerical circulation models as to their ability to depict realistically the prevailing mesoscale circulation features and currents in the upper layers.

APPROACH

The approach is to couple a simple primary productivity model to a skillful data-assimilative physical model, and use the modeled chlorophyll concentration as a tracer of the underlying circulation in the euphotic zone. By comparing modeled chlorophyll concentration fields with those derived from ocean color imagery, it is possible to infer the skill of the circulation model and provide some quantitative estimates. The Gulf of Mexico is used as the test bed, since a skillful data-assimilative model of the Gulf exists at the University of Colorado and has been successfully used for hindcasts and forecasts of the oceanic state. Ten-day composite imagery that is nearly devoid of cloud cover is also available from NASA SeaWiFS for this region. A simple 3-component (NPZ) primary productivity model (Kantha 2003a) forms the backbone of the chlorophyll simulations with the coupled model. The physical model assimilates altimetric SSH anomalies from TOPEX/Poseidon and ERS2 altimeters and MCSST from NOAA AVHRR to reproduce the mesoscale field with considerable fidelity (Kantha and Clayson 2000, Kantha et al. 1999, Schaudt et al. 2001, Kirwan et al. 2003, Kuznetsov et al. 2002, Toner et al. 2001 & 2002). The model chlorophyll then acts as an effective tracer of the underlying circulation as long as significant chlorophyll contrasts exist to highlight the mesoscale feature.

WORK COMPLETED

The coupling was successfully completed, and the coupled model was run for 14 cases during the year 1998, when a large anticyclone pinched off the Loop Current. Fig.1 shows the ten-day average modeled surface chlorophyll concentration for Jan 31-Feb 9, 1998. The large anticyclone is well depicted by the model. Fig. 2 shows the corresponding ten-day composite color imagery from NASA

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14. ABSTRACT

The long-term goal of this effort is to improve the skill of modern 3-D numerical ocean circulation models used for studying the oceans and, in operational centers, for nowcasting/ forecasting the oceanic state.

15. SUBJECT TERMS

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SeaWiFS sensor. The two images are very well correlated. A comprehensive paper on ecosystem models (Kantha 2003a) has been published, along with several related papers on modeling accurately the oceanic upper layers. A final report has been prepared (Kantha 2003b).

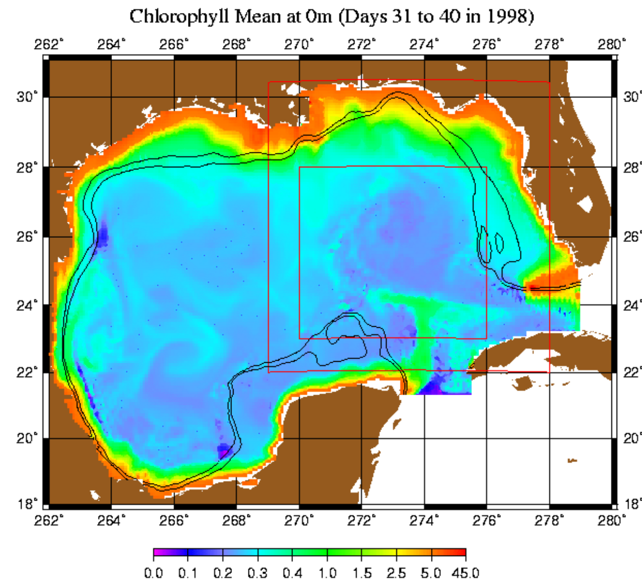

Figure 1. Ten-day ocean color composite image at model resolution from the coupled model for Jan. 31 to Feb. 9, 1998. The large anticyclonic ring still attached to the Loop Current is well depicted by the model. The boxes show the regions in which the model output was correlated with data.

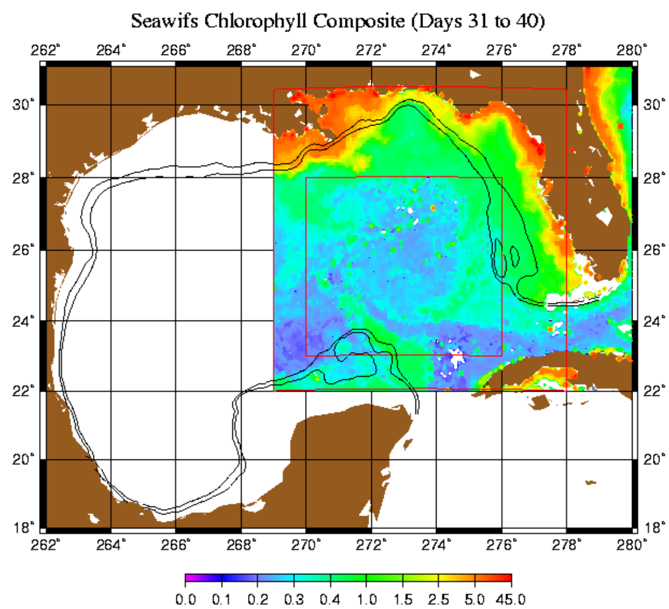

Figure 2. Ten-day ocean color composite image at model resolution from SeaWiFS Jan. 31 to Feb. 9, 1998 (courtesy of Dr. Frank Muller-Karger of University of Southern Florida and Dr. Mike Toner of University of Delaware). The boxes show the regions in which the model output was correlated with data.

RESULTS

This small effort ($60K) was a pilot study to demonstrate the feasibility of using ocean color data to assess the skill of numerical circulation models, with the Gulf of Mexico as the test bed. Table 1 shows the overall statistics for all 14 cases. The model results suggest that when a distinct mesoscale feature is apparent in the ocean color imagery, it can indeed be used to quantify the skill of the numerical circulation model. We recommend that the method be applied to regions of US Navy's strategic interest, such as the Sea of Japan.

Table 1. Correlation Coefficients

Composite Days	Inner Box	Outer Box
31-40	0.91	0.66
41-50	0.94	0.64
51-60	0.95	0.52
61-70	0.89	0.57
71-80	0.73	0.59
81-90	0.62	0.43
91-100	0.89	0.41
101-110	0.86	0.40
111-120	0.92	0.42
121-130	0.91	0.41
131-140	0.39	0.22
141-150	0.41	0.20
151-160	0.37	0.25
161-170	0.34	0.48

IMPACT/APPLICATIONS

Accurate depiction of currents, and circulation features such as mesoscale eddies, fronts and jets, is of great importance to naval operations. Observations are invariably scarce and, increasingly, numerical models are being called upon to satisfy this requirement. A data-assimilative numerical circulation model can overcome the spatio-temporal sampling limitations of in-situ and remote sensing, and can, in addition, provide simulation and nowcast/forecast capabilities. However, it is rather difficult to verify the skill of a model in producing accurate currents and circulation features, simply because the verification data available are severely limited. The dearth of in-situ skill assessment data forces modelers to rely instead on readily available remotely sensed data for model skill assessment. Ocean color imagery is of potential utility in assessing the skill of numerical circulation models. Furthermore, one stands to learn far more about ocean circulation from a skillful primary productivity (aka ecosystem) model coupled to the physical model than the physical model alone. Despite this obvious advantage, not much use has been made in the past, of primary productivity models and ocean color imagery in the interpretation of the underlying circulation! It is clearly time to do so, especially in regions of our Navy's strategic interest.

RELATED PROJECTS

Improving the Skill of Ocean Mixed Layer Models (ONR N00014-03-1-0488)

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